Use of regional distributed hydrological modelling approaches for the design of catchment experimental set up within HyMeX

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Flash floods represent the most destructive natural hazard in the Mediterranean region, causing around one billion Euros worth of damage in France over the last two decades. Flash floods are associated with extreme and rare rainfall events and usually occur in ungauged river basins. Amongst them, small-ungauged catchments are recognized as the most vulnerable to storm driven flash floods. In order to limit the damages to the population, there is a need to improve our understanding and the simulation tools for these events. In order to provide information over a whole region, hydrological models applicable at this scale, and able to take into account the spatial variability of rainfall and catchment characteristics, must be proposed.
This paper presents such a regional distributed approach applied to the 8-9 September 2002 extreme event which affected the Gard region in the south-east of France. In order to identify the variables and catchment characteristics which require improved knowledge, two distributed hydrological models were set up on a set of catchments, with sizes ranging from 2.5 to 99 km^2. The models differ in terms of spatial discretization and process representation. They were forced using radar data with a 1 km2 spatial resolution and 5 min time step. The model parameters were specified using the available information, namely a digital terrain model and a soil data base. The latter provides information about soil texture, soil porosity and soil depths. Soil hydraulic properties were defined using pedo-transfer functions.
Data from a post-flood field survey of maximum peak discharge were used to assess the quality of the simulations. A reasonable agreement between modeled and observed values was obtained. Sensitivity studies were then performed to asses the respective impact of rainfall estimation and soil variability on the simulated discharge. The analysis shows that rainfall remains the first controlling factor of flash flood dynamics and that high resolution spatial and temporal data are required in order to properly simulate peak discharge and flow dynamics for a range of scales. The river bed roughness also influences the peak intensity and time. Soil spatial representation is shown to have a significant role on runoff coefficients and on the spatial variability of saturation dynamics. For some catchments, the impact of soil properties on the simulated discharges was of the same order of magnitude as the impact of the rainfall estimation.
The results were very similar for the two distributed models, despite their difference in structure. They show that the poor knowledge of soil properties, mainly soil depth, initial soil water content and saturated hydraulic conductivity is detrimental to robust estimation of discharge. A better knowledge of these variables is therefore recommended. In particular soil depth is required. Post field estimation of peak discharge were very valuable for the regional assessment of the methodology, but must be complemented with data of the whole hydrographs to reduce the uncertainty in flow dynamics and runoff production. Effort towards improved quantitative rainfall estimation using a network of radars must also be continued.

The results of the study are used in the design of the future HyMeX experiment, aiming at improving the Mediterranean water balance and the knowledge of extreme events. A strategy based on gauged nested catchments is set up. Detailed measurements of the water balance (discharge, soil moisture, evapotranspiration) are proposed on small catchments of about 1 km2 in order to improve the process understanding. An intermediate scale is defined for catchments of about 100 km2 with distributed hydrometry, based on Large Scale Image Velocimetry to tackle the change of scale problem. Finally, operational data are used at larger scale of about 1000 km2. These data will also be useful to propose improved modelling tools applicable on ungauged catchments.

The modelling approach is currently enriched to provide continuous simulations in order to study the sensitivity of the hydrological response to initial conditions. These results will also be used to determine where observations of soil moisture offer the best potential for improving our understanding.